

Quinton-Scribner Cannulas For Hemodialysis

Review of Four Years' Experience

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■ *Data on a study group of 52 maintenance hemodialysis patients cannulated with Quinton-Scribner cannula in a four-year period were analyzed. The average period of dialysis was 11.8 months with either a pumped coil or a pumpless Kiil artificial kidney system. One hundred and forty-five cannulations were performed. The mean arterial cannula survival was 7.8 months and the mean venous cannula survival was 7.2 months. The exceptional longevity of cannula survival occurred despite the high incidence of atherosclerotic changes at operation and the advanced mean age (47 years) of the patients. The cannula longevity may be partially related to the technique used and to meticulous surgical care given the patient before and after cannulation.*

Complications from cannulation included two deaths, one from septic pulmonary embolism of Staphylococcus origin, and one from acute Pseudomonas endocarditis. A total of 36 infections of cannulas were recognized, the majority being due to Staphylococcus aureus, but 28 percent being secondary to Gram-negative bacteria.

SEMIPERMANENT ARTERIOVENOUS cannula systems^{1,2} have been the unique surgical contribution which has made maintenance hemodialysis possible. Since 1964, chronic hemodialysis has been conducted at Mt. Sinai Hospital in Los Angeles, and Quinton-Scribner cannula systems have been employed for all patients. This report summarizes the surgical procedures, problems, and significant

cannula complications for cannulations performed from November 1964 to December 1968, and includes data from the in-hospital program (coil, blood pump assist dialysis) and the home hemodialysis program (two-layer Kiil, pumpless system).

Materials and Methods

Ninety-three uremic patients were cannulated during the study period. All cannula operations were performed by the first three authors and only

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TABLE 1.—*Age Distribution of Patients*

<i>Age (years)</i>	<i>No. of Patients</i>
<20	1
20-29	9
30-39	11
40-49	18
50-60	13

one patient was lost to follow-up. By December 1968, the hemodialysis patient population totaled 37; each patient was hemodialyzed either in the hospital two or three times a week, or at home three or five times a week.

Twenty-four of the 93 patients were cannulated for treatment of acute rather than chronic renal failure, and ten for pre-transplantation dialysis. These latter categories of patients are excluded. The remaining 52 patients make up the study group and were dialyzed an average of 11.8 months (range 1 to 32 months). Each patient was dialyzed approximately 16 to 30 hours a week with either a two-layer Kiil or Travenol® twin-coil artificial kidney. One-hundred and forty-five arterial and venous cannulas were implanted in these patients during the four-year period.

Table 1 shows the age distribution of the 20 women and 32 men. Sixty percent of the patients in this program were over 40 years of age.

Cannula Materials

During the four years, several changes were made in the cannula equipment. In 1964 and 1965, teflon double-break shunts^{3,4} were employed, with metal joint and crimp rings at the teflon-silastic union, and with cannula tips 4 cm in length. During 1966, the internal metal rings were replaced with fine ligature. The double-break teflon loop was replaced with a single-break male-female teflon connection. Cannula tips were shortened and tips of 2 to 2.5 cm have been used since mid-1966, with only 1 cm of the tip inserted into the artery or vein. Early in 1967, the single-break connection between the two silastic cannulas was changed to a single piece of teflon beveled at both ends.

Surgical Considerations

Preoperative clinical evaluation of the status of arteries and veins available for cannulation is critical. Presence of limb edema or of infection required temporary delay in operation. Absence

of pulses or veins, or obliteration of veins by previous phlebitis, eliminates the possibility of using that particular limb for cannulation, and rarely makes any cannulation impossible. Leg cannulas are preferred, especially for home-dialysis patients. The posterior tibial artery and the greater saphenous vein are usually used, but anterior tibial and peroneal arteries, and short saphenous and other superficial leg veins were also employed.

The surgical procedure was usually easier to perform on the arm, and that site was preferred for short-term use in cases of acute renal failure or pre-transplantation dialysis. The radial artery and any superficial vein 3 mm or larger in diameter are usually cannulated in these instances.

Cannulation Technique

Cannulations were done in an operating room under local anesthesia and light premedication. In this procedure the vessel to be cannulated is ligated with 4-0 Polydek® at its distal limit in the wound, and the ligature tails are used for traction. The caliber of the vessel is estimated, and a teflon tip* of appropriate size (not the largest tip possible) is selected. The tip is shortened to 2 cm by cutting off the non-tapered end sharply; only 1 cm of the tip is inserted into the blood vessel. We believe the shortened tips reduce angulation problems.

This teflon-silastic union is secured with a single loop of 4-0 Polydek, tied snugly enough to indent the silastic. The silastic tubing must be selected from available 180° loops, reverse (360°) loops and straight pieces to suit the particular anatomic features of the vessel and cannulation site; care must be taken with leg arterial cannulas not to place them too distally lest gradual postoperative cannula egress, skin erosion or angulation occur.

A subcutaneous tunnel is developed to accommodate the silastic extension, and a small stab incision is made for percutaneous exit of the "step" portion of the tubing. Silastic tubing with "steps" is usually but not always employed.

A small incision is made in the vessel, usually cruciate in shape, to avoid rolling intima during tip insertion in arteries which may be brittle. Arterial bleeding is controlled by gentle traction of Polydek loops around the proximal portion of the artery. The cannula tip is then carefully inserted

*Obtained from Extracorporeal and Medical Specialties Co., Inc., Mt. Laurel TWP, New Jersey. Teflon cannula tip sizes 18-13.

into the vessel, and is tied in place by one or two pieces of 4-0 Polydek. This insertion and fixation of the tip, particularly in the artery, is the most critical and most difficult step of the cannulation procedure, and an assistant may be required. The tails of the ligature on the distal vessel are tied snugly over the silastic tubing into which the teflon tip was inserted. These tails are then tied again, this time to the tails of one of the ligatures fixing the cannula tip in the vessel, forming a harness-sling which prevents egress of the cannula from the vessel.

The cannula is then irrigated with heparinized saline solution. Blood flow rate from the arterial cannula is estimated. It is important that the cannula tip lie in the vessel without angulation, pressure or torsion from surrounding structures. Arterial cannula obstruction may occur if a flap of intima is pushed ahead of the teflon tip; it can be corrected by recannulation 1 to 2 cm cephalad. This complication can usually be prevented by avoiding the use of too large a teflon tip.

The vein is then cannulated in a similar manner. The arterial and venous cannula limbs are next connected by means of a 3 cm length of double-beveled teflon tubing. Flow through the shunt may be sluggish at first ("bubble-transit time" greater than three seconds) but it usually improves within minutes. Failure of rapid improvement in flow rate usually results in clotting within a few hours unless the obstruction is corrected.

Hemostasis is obtained with electro-cautery. Wounds are irrigated with 0.5 percent solution of kanamycin, and are closed by plastic technique with subcuticular 4-0 nylon. After closure, shunt flow is rechecked and the arteriovenous connection is bridged with Air-Vent® tape. The dressing is completed with a 4" Kling® roll.

Postoperative Management

Formerly plaster splinting was used to insure immobilization, but present practice is to elevate the cannulated limb and tell the patient not to move it. For leg cannulas, after three days of complete bed rest, wheelchair and crutches are allowed, with no weight-bearing on the cannulated limb for three weeks. Progressive ambulation is allowed thereafter. Cannulated arms are placed in slings for two or three weeks. Finger motion is encouraged to prevent muscle atrophy but wrist and forearm motion should be kept to a minimum during the first three weeks.

Preferably the dressing is not disturbed for five to seven days. Occasionally, however, a patient requires dialysis immediately following cannulation. Cannula displacement due to subcutaneous bleeding with dialysis in the early postoperative period can result in early cannula infection or failure. After the early postoperative period, cannula exit sites are cleansed before each dialysis with tap water and Betadine® or PhisoHex® or 3 percent hydrogen peroxide or 70 percent ethanol.

Care of Cannula Complications

Cannula problems usually are first seen and are resolved primarily by the dialysis nurses. Clotting and infection are the most common complications requiring special attention. Declotting, usually a nursing procedure, is carried out in the manner outlined by Pendras and Smith.⁵ After declotting, cannula angiography⁶ is obtained in anticipation of the need for cannula revision. Progressive deterioration of cannula function, often a forewarning of clotting, is recognized by diminution of arterial flow or by increase in venous resistance as measured during dialysis. Cannula angiography is performed to investigate such problems of cannula function. Heparin or warfarin are frequently used following cannula declotting, and anticoagulation is maintained until the underlying problem is resolved.

Purulent discharge at the point of insertion is routinely cultured. If infection is suspected, antibiotic treatment is begun immediately, often before the culture report is available. Overt cannula infection treatment requires a combination of hot, moist compresses, limb immobilization and elevation, and liberal use of appropriate antibiotics.

Cannula Revisions

Revisions are carefully planned to permit conservation of remaining unused arteries and veins for future cannulations. When possible, a new cannula tip is implanted one to two inches cephalad to the faulty tip site. However, in the presence of infection, particularly when cellulitis is present, new cannulation in a separate limb may be necessary. Segmental venous obstructions are often encountered during revisions. These characteristically occur as venous stenosis at the vessel-teflon tip or from 1 to 6 cm cephalad to the teflon tip. Occasionally, obstruction to flow will be

TABLE 2.—*Serious Complications of Cannulation in Series of 52 Patients*

<i>Complication</i>	<i>No. of Patients</i>
Severe infection of cannula requiring cannula removal	8
Septicemia	
Staphylococcus aureus	2
Pseudomonas (one death)	2
Septic pulmonary embolism (one death)	4
Arterial false aneurysm	8
Bleeding, severe, requiring cannula removal	2

TABLE 3.—*Organisms Identified in Cannula Infections*

<i>Pathogen</i>	<i>No. of Cases</i>
Staphylococcus aureus	19
Staphylococcus epidermitis	6
Staphylococcus albus	1
Pseudomonas	8
Klebsiella aerobacter group	2

found entirely due to venospasm. Reliance is placed in such cases on preoperative cannula angiograms to help rule out mechanical obstructions.

Results

Treating the 52 patients who were long-term participants in the dialysis program made up 49.5 patient-years of experience.

Transplantations, Deaths, and Transfers

Of the 52 long-term dialysis patients, 16 died, 15 others left the program following renal homo-transplantation, and one transferred to another institution for care. Data concerning these patients' last cannula sets have been excluded.

The serious complications of cannulation are listed in Table 2.

Two deaths were due to sepsis, septic pulmonary embolism of staphylococcus origin in one case and acute pseudomonas endocarditis in the other. In each case a Quinton-Scribner cannula was the probable source of infection, as cultures of the circulating blood and of material from the infected cannulas were identical. The remaining serious complications of cannulas usually required the removal of the cannula system, except in one instance of a cannula exit site infection with staphylococcal epidermitis and associated septicemia. In this instance, cure was effected by long-term antibiotic treatment.

A total of 36 distinctly separate infections of Scribner cannulas were recognized in these pa-

CANNULA SURVIVAL, SCRIBNER SHUNTS

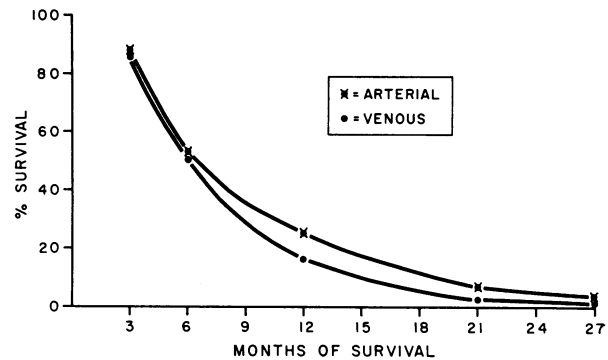


Chart 1.—Survival of Quinton-Scribner cannulas in 52 patients.

tients. The principal pathogens identified by culture in the clinical infections of cannulas are listed in Table 3.

Infections ranged from minimal inflammation to abscesses or severe cellulitis. Erythema without tenderness at the cannula exit sites was not a frequent early sign of infection in this study. Mild infections were also identified by tenderness about the implanted cannula or by purulent discharge around the tubing. At times, suppurative discharge was found only by "milking" the subcutaneous tunnel. Bleeding around cannulas was common but it reached serious proportions only twice, and in those instances cannula revision was necessary. Failure of response to treatment of cannula infection or further complication such as bleeding, false aneurysm or septicemia were considered urgent indications for cannula removal.

In two of the eight instances of pseudomonas infection, severe phlebitis eventually occurred. In these cases infections advanced from an insidious onset through a stage of minimal clinical findings, responded poorly to treatment, and progressed to septicemia resulting in acute endocarditis and death in one case and in septic pulmonary embolism, with recovery after cannula removal, in the other.

Cannula Survival

For calculating cannula survival statistics, all functioning cannulas less than three months old were excluded. Seventy-two arterial cannulas implanted during the four-year period provide the material for calculation of survival data presented in Chart 1. Duration of cannula survival was cal-

culated from the date of cannula insertion. Mean arterial cannula survival was 7.8 months. However, 22 of the arterial cannulas included in these data were still functioning at the time the data were compiled. No significant difference in survival time ($P>0.5$) was evident between arterial cannulas in the arm and those in the leg. Fifty-four arterial leg cannulas functioned an average of 7.7 months (range 1 to 27 months), while 18 arm cannulas survived a mean 8.0 months (range 3 to 26 months).

Chart 1 also shows the comparable venous cannula survival data. Mean survival for 73 venous cannulas was 7.2 months. Fourteen of the venous cannulas included were still functioning after periods of from 3 to 28 months at the time the data were compiled. A mean survival of 6.7 months (range 2 to 19 months) was obtained for 15 arm venous cannulas, as compared with 7.4 months (range 2 to 27 months) for 58 leg venous cannulas—not a significant difference ($P>0.5$). There also was no significant difference ($P>0.2$) between the mean survival of arm arterial cannulas (8.0 months) and that of arm venous cannulas (6.7 months).

Discussion

Acute hemodialysis in man was first performed in 1943.⁷ Treatment of patients in chronic renal failure became practical in 1960 with the development of the arteriovenous teflon shunt. The teflon cannula body and tip was replaced by a silastic cannula with teflon tip and this silastic teflon cannula system was reported in 1962 by Quinton et al.⁴ The cannula experience of this newer system at the Seattle Artificial Kidney Center was reviewed in 1966 by Pendras and Smith.⁵ In reviewing 47.6 patient-years cannula experience over a four-year period, they found cannula survivals of 14.3 months average for arterial (range 1.3 to 38 months) and 11.7 months for venous cannulas (range 1.3 to 51 months).

Other investigators, however, have been unable to duplicate the cannula longevity reported by the Seattle group. Cannula data presented by Rubini et al⁸ indicated an average cannula survival time of 8.1 months for both arterial and venous cannulas in 16 patients treated an average of 15.6 months each. The ages of these patients were not given but since the patients were carefully selected from a large patient population by medical and

other criteria, it is probable that they had minimal or little peripheral vascular disease.

McDonald and associates⁹ reported an average venous and arterial cannula life of 4 months and 4.8 months, respectively, in a total of 105 months' cannula experience with 11 patients. Less satisfactory results were obtained by Wilson et al¹⁰ in 80 patients. They reported mean "shunt life" of 2.2 months in 39 patients without distinction between arterial and venous cannulas.

The mean cannula longevity in this report is remarkable considering the high mean age of the patient population (47 years) and the frequency of moderate to severe peripheral vessel atherosclerotic narrowing and changes seen at surgical operation. The most common cannula complications were infection and impaired blood flow due to stenosis, with resultant inadequate dialysis or clotting. Chronic infection, often subclinical for days to weeks, probably contributed to venous stenosis, arterial false aneurysm, and bleeding at the cannula exit site. The cannula exit sites are constant portals of entry for bacteria. We suspect that perivascular lymphangitis may be continuously present, and may account for the frequent findings of segmental venous stenosis and obstruction several centimeters cephalad of the teflon tip.

Frequently, other factors are associated with cannula failure. Underlying primary vascular disease (vasculitis, arteriosclerosis, phlebitis) has been present in some cases. Hypotension, hypovolemia or reduced cardiac output resulting from major abdominal operations or bleeding resulted in cannula thrombosis in three cases. In each of these cases of normal cannula function resumed on removal of the clot but cannula malfunction occurred subsequently, necessitating surgical revision within two months, possibly because of endothelial damage at the time of clotting.¹¹

If the vessels available for cannulation are so small that the smallest cannula tip (No. 18) can be inserted only after forceful dilatation of the vessel, there is little hope for cannula longevity.

Some degree of manipulation of the cannula always is necessary during union with the artificial kidney. Since tugging and torsion upon the tubing contributes in some measure to cannula failures, it should be kept to a minimum by all personnel who handle the cannulas. Progressive irreversible egress of the subcutaneous portion of silastic tubing occurs with excessive manipulation.

Cannula materials *per se* have been indicated as a source of thrombosis. In our experience, only three instances of spontaneous clotting were found which were unrelated to significant cannula stenosis or obstruction of flow as seen on angiograms or at operation, and each of these exceptions was associated with acute hypotensive or hypovolemic states.

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PREMATURE LABOR AND DECREASED HEART SIZE

"A great number of premature labors occur unexpectedly, without recognizable etiology. It begins to appear that many of these may be on a circulatory basis. We and others have reported that patients with a decreased heart size during pregnancy have an increased chance of premature labor. With decreasing heart volume, there's a great increase in the rate of prematurity—1.5 percent in patients with a heart volume of 750 ml or more compared to 24 percent when it's below 350 ml. The small heart, probably associated with decreased cardiac output and a reduction of uterine blood flow, may result in a relative uterine hypoxia and myometrial irritability with subsequent onset of premature labor. It has been our experience, as well as that of others, that reduction of the work load of those patients with smaller than normal heart sizes will drastically reduce the anticipated high risk of prematurity."

—EDWARD BISHOP, M.D., Philadelphia
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